

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number  
WO 01/18354 A1

(51) International Patent Classification: E21B 43/10

(74) Agent: MURGITROYD & COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).

(21) International Application Number: PCT/GB00/03406

(22) International Filing Date:  
6 September 2000 (06.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
9920935.5 6 September 1999 (06.09.1999) GB

(71) Applicant (for all designated States except US): e2TECH LIMITED [GB/GB]; 47 Woodside Road, Bridge of Don, Aberdeen AB23 8EF (GB).

(81) Designated States (national): AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

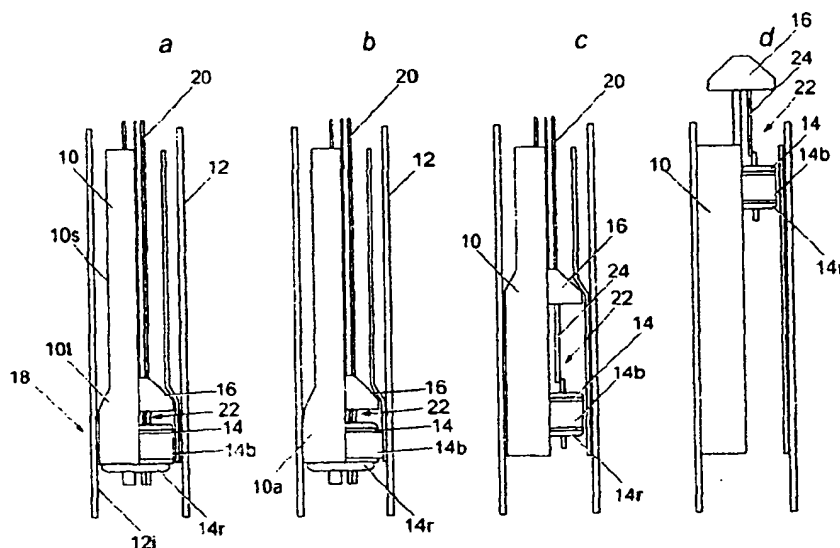
Published:

— With international search report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventor; and  
(75) Inventor/Applicant (for US only): OOSTERLING, Peter [NL/NL]; Noordeindseweg 128, NL-2651 CX Berkel en Rodenrijs (NL).

(54) Title: APPARATUS FOR AND METHOD OF ANCHORING A FIRST CONDUIT TO A SECOND CONDUIT



(57) Abstract: Apparatus and methods are disclosed for anchoring a first conduit (10) to a second conduit (12). The first conduit (10) is typically an expandable conduit whereby a portion of the first conduit is expanded by applying a radial force thereto to provide an anchor and/or seal between the first (10) and second (12) conduits. An inflatable device (14) is provided that can be used to provide a temporary anchor whilst the first (expandable) conduit (10) is radially expanded. An expander device (16) that is capable of applying a radial expansion force to the first conduit (10) is optionally attached to the inflatable device (14).



WO 01/18354 A1

BEST AVAILABLE COPY

1   **"Apparatus for and Method of Anchoring a First Conduit**  
2   **to a Second Conduit"**

3

4   The present invention relates to an apparatus for and a  
5   method of anchoring a first conduit to a second  
6   conduit, the apparatus and method particularly, but not  
7   exclusively, using an inflatable device to provide a  
8   temporary anchor.

9

10   A borehole is conventionally drilled during the  
11   recovery of hydrocarbons from a well, the borehole  
12   typically being lined with a casing. Casings are  
13   installed to prevent the formation around the borehole  
14   from collapsing. In addition, casings prevent unwanted  
15   fluids from the surrounding formation from flowing into  
16   the borehole, and similarly, prevents fluids from  
17   within the borehole escaping into the surrounding  
18   formation.

19

1 Boreholes are conventionally drilled and cased in a  
2 cascaded manner; that is, casing of the borehole begins  
3 at the top of the well with a relatively large outer  
4 diameter casing. Subsequent casing of a smaller  
5 diameter is passed through the inner diameter of the  
6 casing above, and thus the outer diameter of the  
7 subsequent casing is limited by the inner diameter of  
8 the preceding casing. Thus, the casings are cascaded  
9 with the diameters of the casing lengths reducing as  
10 the depth of the well increases. This gradual  
11 reduction in diameter results in a relatively small  
12 inside diameter casing near the bottom of the well that  
13 could limit the amount of hydrocarbons that can be  
14 recovered. In addition, the relatively large diameter  
15 borehole at the top of the well involves increased  
16 costs due to the large drill bits required, heavy  
17 equipment for handling the larger casing, and increased  
18 volumes of drill fluid that are required.

19

20 Each casing is typically cemented into place by filling  
21 cement into an annulus created between the casing and  
22 the surrounding formation. A thin slurry cement is  
23 pumped down into the casing followed by a rubber plug  
24 on top of the cement. Thereafter, drilling fluid is  
25 pumped down the casing above the cement that is pushed  
26 out of the bottom of the casing and into the annulus.  
27 Pumping of drilling fluid is stopped when the plug  
28 reaches the bottom of the casing and the wellbore must  
29 be left, typically for several hours, whilst the cement  
30 dries. This operation requires an increase in rig time  
31 due to the cement pumping and hardening process, that  
32 can substantially increase production costs.

1

2 It is known to use a pliable casing that can be  
3 radially expanded so that an outer surface of the  
4 casing contacts the formation around the borehole. The  
5 pliable casing undergoes plastic deformation when  
6 expanded, typically by passing an expander device, such  
7 as a ceramic or steel cone or the like, through the  
8 casing. The expander device is propelled along the  
9 casing in a similar manner to a pipeline pig and may be  
10 pushed (using fluid pressure for example) or pulled  
11 (using drill pipe, rods, coiled tubing, a wireline or  
12 the like).

13

14 Lengths of expandable casing are coupled together  
15 (typically by threaded couplings) to produce a casing  
16 string. The casing string is inserted into the  
17 borehole in an unexpanded state and is subsequently  
18 expanded using the expander device, typically using a  
19 substantial force to facilitate the expansion process.  
20 However, the unexpanded casing string requires to be  
21 anchored either at or near an upper end or a lower end  
22 thereof during the expansion process to prevent undue  
23 movement. This is because when the casing string is in  
24 an unexpanded state, an outer surface of the casing  
25 string does not contact the surrounding borehole  
26 formation or an inner face of a pre-installed casing or  
27 liner (until at least a portion of the casing has been  
28 radially expanded), and thus there is no inherent  
29 initial anchoring point.

30

31 Slips are conventionally used to temporarily anchor the  
32 unexpanded casing to the borehole during the expansion

1 process. Slips are generally wedge-shaped, steel,  
2 hinged portion that provide a temporary anchor when  
3 used. Slips are actuated whereby the wedge-shaped  
4 portions engage with the surrounding borehole formation  
5 or a casing or liner.

6  
7 However, the mechanical configuration of slips often  
8 causes damage to the casing or liner. In some cases,  
9 the damage causes the slip to fail due to a loss of  
10 mechanical grip. Slip-type devices in open-hole  
11 engaging formation are often prone to slippage also.

12  
13 According to a first aspect of the present invention,  
14 there is provided an apparatus for anchoring a first  
15 conduit to a second conduit, the apparatus comprising  
16 an inflatable device for engaging with the first  
17 conduit, wherein the inflatable device is inflatable to  
18 facilitate anchoring of the first conduit to the second  
19 conduit.

20  
21 According to a second aspect of the present invention,  
22 there is provided a method of anchoring a first conduit  
23 to a second conduit, the method comprising the steps of  
24 providing a first conduit, providing an inflatable  
25 device in contact with the first conduit, running the  
26 first conduit and inflatable device into the second  
27 conduit, and subsequently inflating the inflatable  
28 device to facilitate anchoring of the first conduit to  
29 the second conduit.

30  
31 According to a third aspect of the present invention,  
32 there is provided a method of anchoring an expandable

1 conduit to a second conduit, the method comprising the  
2 steps of providing an expandable conduit, running the  
3 first conduit into the second conduit, passing an  
4 inflatable device into the conduit, and subsequently  
5 inflating the inflatable device to facilitate anchoring  
6 of the expandable conduit to the second conduit.

7  
8 The first conduit is typically an expandable conduit.

9  
10 The first or expandable conduit may comprise any type  
11 of expandable conduit that is capable of sustaining  
12 plastic and/or elastic deformation. The first conduit  
13 typically comprises an expandable liner, casing or the  
14 like. The second conduit may comprise any type of  
15 conduit. The second conduit typically comprises a  
16 liner, casing, borehole or the like.

17  
18 The inflatable device typically comprises an inflatable  
19 balloon-type portion coupled to a ring. This allows a  
20 string or the like to be passed through the inflatable  
21 device in use.

22  
23 Optionally, the inflatable device includes an expander  
24 device. The expander device is optionally  
25 telescopically coupled to the inflatable device, so  
26 that when the expander device is moved a certain  
27 distance, the inflatable device is deflated and  
28 subsequently moves with the expander device.

29  
30 Alternatively, the expandable device may be releasably  
31 attached to the inflatable device, typically using a  
32 latch mechanism.

1

2 The inflatable device may be located within the  
3 expandable conduit. Alternatively, the inflatable  
4 device may be coupled at or near an upper end of the  
5 expandable conduit, or at or near a lower end of the  
6 expandable conduit. The inflatable device may be  
7 coupled to the expandable conduit using any suitable  
8 connection.

9

10 The inflatable device is typically inflated to expand  
11 the expandable conduit whereby the expandable conduit  
12 contacts the second conduit, thereby providing an  
13 anchor. In this embodiment, the expandable conduit is  
14 optionally provided with a slotted portion to  
15 facilitate expansion. This is advantageous as the  
16 contact between the expandable conduit and the second  
17 conduit provides the anchor, and forces applied to the  
18 expandable conduit are mainly channelled into the  
19 second conduit via the expandable conduit and not the  
20 inflatable device.

21

22 Alternatively, the inflatable device is inflated  
23 whereby a portion thereof directly contacts the second  
24 conduit to provide an anchor.

25

26 The expander device is typically manufactured from  
27 steel. Alternatively, the expander device may be  
28 manufactured from ceramic, or a combination of steel  
29 and ceramic. The expander device is optionally  
30 flexible.

31

1 The expander device is optionally provided with at  
2 least one seal. The seal typically comprises at least  
3 one O-ring.

4

5 The method optionally comprises one, some or all of the  
6 additional steps of inserting an expander device into  
7 the expandable conduit, operating the expander device  
8 to expand the expandable conduit, deflating the  
9 inflatable device, and removing the expander device  
10 and/or the inflatable device from the expandable  
11 conduit and/or the second conduit.

12

13 The method optionally comprises one, some or all of the  
14 additional steps of attaching an expander device to the  
15 inflatable device, operating the expander device to  
16 expand the expandable conduit, re-attaching the  
17 expander device to the inflatable device, deflating the  
18 inflatable device, and removing the expander device  
19 and/or the inflatable device from the expandable  
20 conduit and/or second conduit.

21

22 The expander device is typically operated by propelling  
23 it through the expandable conduit using fluid pressure.  
24 Alternatively, the expander device may be operated by  
25 pigging it along the expandable conduit using a  
26 conventional pig or tractor. The expander device may  
27 also be operated by propelling it using a weight (from  
28 the string for example), or may be pulling it through  
29 the expandable conduit (e.g. using drill pipe, rods,  
30 coiled tubing, a wireline or the like).

31



1    Optionally, the inflatable device may act as a seal  
2    whereby fluid pressure can be applied below the seal.

3

4    Embodiments of the present invention shall now be  
5    described, by way of example only, with reference to  
6    the accompanying drawings, in which:-

7            Figs 1a to 1d are successive stages in anchoring  
8            and expanding an expandable conduit within a  
9            second conduit using a first embodiment of an  
10           inflatable device;

11           Figs 2a to 2d are successive stages in anchoring  
12           and expanding an expandable conduit within a  
13           borehole to tie back the expandable conduit to a  
14           casing using a second embodiment of an inflatable  
15           device;

16           Figs 3a to 3d are successive stages in anchoring  
17           and expanding an expandable conduit within a  
18           second conduit using a third embodiment of an  
19           inflatable device;

20           Fig. 4a is a front elevation showing a first  
21           configuration of a friction and/or sealing  
22           material that can be applied to an outer surface  
23           of the conduits shown in Figs 1 to 3;

24           Fig. 4b is an end elevation of the friction and/or  
25           sealing material of Fig. 4a;

26           Fig. 4c is an enlarged view of a portion of the  
27           material of Figs 4a and 4b showing a profiled  
28           outer surface;

29           Fig. 5 is a schematic cross-section of an  
30           expandable conduit that can be used with the  
31           present invention having an alternative

1 configuration of a friction and/or sealing  
2 material;  
3 Fig. 6a is an front elevation of the friction  
4 and/or sealing material of Fig. 5; and  
5 Fig. 6b is an end elevation of the friction and/or  
6 sealing material of Fig. 6a.

7  
8 Referring to Fig. 1, there is shown in sequence (Figs  
9 1a to 1d) successive stages of anchoring an expandable  
10 conduit 10 to a casing 12 provided in a borehole (not  
11 shown), the borehole typically being drilled to  
12 facilitate the recovery of hydrocarbons. The  
13 expandable conduit 10 is typically an expandable liner  
14 or casing, but any type of expandable conduit may be  
15 used.

16  
17 The borehole is conventionally lined with casing 12 to  
18 prevent the formation around the borehole from  
19 collapsing and also to prevent unwanted fluids from the  
20 surrounding formation from flowing into the borehole,  
21 and similarly, prevents fluids from within the borehole  
22 escaping into the surrounding formation. It should be  
23 noted that the casing 12 may comprise any type of  
24 conduit, such as a pipeline, a liner, a casing, a  
25 borehole or the like.

26  
27 An inflatable device 14, that in this embodiment has an  
28 expander device 16 telescopically attached thereto, is  
29 positioned within the expandable conduit 10 before the  
30 conduit 10 is inserted into the casing 12.

31

1 Referring to Fig. 1a, the conduit 10 with the  
2 inflatable device 14 and expander device 16 located  
3 therein is run into the hole to the required setting  
4 depth. As can be seen in Fig. 1a, a lower end 10l of  
5 the expandable conduit 10 is radially expanded  
6 (indicated generally at 18) to allow the inflatable  
7 device 14 and the expander device 16 to be located  
8 therein. It will be appreciated that although Figs 1a  
9 to 1d show the inflatable device 14 and expander device  
10 16 located at or near the lower end 10l of the conduit  
11 10, the inflatable device 14 and/or the expander device  
12 16 may also be located at or near an upper end of the  
13 conduit 10. In this case, the expander device 16 is  
14 propelled downwardly using, for example, the weight of  
15 a string, fluid pressure or any other conventional  
16 method.

17  
18 The inflatable device 14 may be of any suitable  
19 configuration, but is typically a device that has an  
20 inflatable annular balloon-type portion 14b that is  
21 mounted on an annular ring 14r. The annular ring 14r  
22 allows a string, wireline or the like to be passed  
23 through the inflatable device 14 as required. This is  
24 particularly advantageous where the inflatable device  
25 14 is positioned at the upper end of the conduit 10.  
26 Thus, substantially full-bore access is still possible.

27  
28 Referring to Fig. 1b, the inflatable device 14 is  
29 inflated to expand the inflatable annular balloon-type  
30 portion 14b. As the balloon-type portion 14b expands,  
31 an anchor portion 10a of the conduit 10 is also  
32 expanded. The anchor portion 10a is expanded by the

1 inflatable device 14 until it contacts the casing 12,  
2 as shown in Fig. 1b. This contact between the anchor  
3 portion 10a of the expandable conduit 10 and casing 12  
4 provides an anchor point and/or a seal between the  
5 expandable conduit 10 and the casing 12. The outer  
6 surface of the anchor portion 10a may be suitably  
7 profiled (e.g. ribbed) or coated with a friction and/or  
8 sealing material 100 (Figs 4a to 4c) to enhance the  
9 grip of the conduit 10 on the casing 12. The friction  
10 and/or sealing material 100 may comprise, for example,  
11 any suitable type of rubber or other resilient  
12 materials. It should be noted that the friction and/or  
13 sealing material 100 can be provided on an outer  
14 surface 10s of the conduit 10 at various axially  
15 spaced-apart locations.

16

17 Referring to Figs 4a to 4c, the friction and/or sealing  
18 material 100 typically comprises first and second bands  
19 102, 104 that are axially spaced apart along a  
20 longitudinal axis of the conduit 12. The first and  
21 second bands 102, 104 are typically axially spaced by  
22 some distance, for example 3 inches (approximately  
23 76mm) .

24

25 The first and second bands 102, 104 are preferably  
26 annular bands that extend circumferentially around the  
27 anchor point 10a of the conduit 10, although this  
28 configuration is not essential. The first and second  
29 bands 102, 104 typically comprise 1 inch wide  
30 (approximately 25.4mm) bands of a first type of rubber.  
31 The friction and/or sealing material 100 need not  
32 extend around the full circumference of the conduit 10.

1  
2 Located between the first and second bands 102, 104 is  
3 a third band 106 of a second type of rubber. The third  
4 band 106 preferably extends between the first and  
5 second bands 102, 104 and is thus typically 3 inches  
6 (approximately 76mm) wide.

7  
8 The first and second bands 102, 104 are typically of a  
9 first depth. The third band 106 is typically of a  
10 second depth. The first depth is optionally larger  
11 than the second depth, although they are typically the  
12 same, as shown in Fig. 4a. The first and second bands  
13 102, 104 may protrude further from the surface 10s than  
14 the third band 106, although this is not essential.

15  
16 The first type of rubber (i.e. first and second bands  
17 102, 104) is preferably of a harder consistency than  
18 the second type of rubber (i.e. third band 106). The  
19 first type of rubber is typically 90 durometer rubber,  
20 whereas the second type of rubber is typically 60  
21 durometer rubber. Durometer is a conventional hardness  
22 scale for rubber.

23  
24 The particular properties of the rubber may be of any  
25 suitable type and the hardnesses quoted are exemplary  
26 only. It should also be noted that the relative  
27 dimensions and spacings of the first, second and third  
28 bands 102, 104, 106 are exemplary only and may be of  
29 any suitable dimensions and spacing.

30  
31 As can be seen from Fig. 4c in particular, an outer  
32 face 106s of the third band 106 can be profiled. The

1 outer face 106s is ribbed to enhance the grip of the  
2 third band 106 on an inner face 12i of the casing 12.  
3 It will be appreciated that an outer surface on the  
4 first and second bands 102, 104 may also be profiled  
5 (e.g. ribbed).

6  
7 The two outer bands 102, 104 being of a harder rubber  
8 provide a relatively high temperature seal and a back-  
9 up seal to the relatively softer rubber of the third  
10 band 106. The third band 106 typically provides a  
11 lower temperature seal.

12  
13 Referring to Fig. 5, there is shown an alternative  
14 conduit 120 that can be used in place of conduit 10.  
15 Conduit 120 is substantially the same as conduit 10,  
16 but is provided with a different configuration of  
17 friction and/or sealing material 122 on an outer  
18 surface 120s.

19  
20 The expandable conduit 120 is provided with a pre-  
21 expanded portion 120e in which an expander device (e.g.  
22 expander device 16) and/or an inflatable device (e.g.  
23 device 14) may be located whilst the conduit 120 is run  
24 into a borehole or the like. It should be noted that  
25 the expander device need not be located in the conduit  
26 120 whilst it is being run into the borehole, and can  
27 be located in the conduit 120 once it is in place.

28  
29 As shown in Fig. 5, the expandable conduit 100 is  
30 provided with the friction and/or sealing material 122  
31 at at least one location. The fiction and/or sealing  
32 material 122 is applied to the outer surface 120s of

1 the conduit 120 at axially spaced apart locations,  
2 typically spaced from one another by around 12 inches  
3 (approximately 305mm).

4  
5 The friction and/or sealing material 122 is best shown  
6 in Figs 6a and 6b. The friction and/or sealing  
7 material 122 is in the form of a zigzag. In this  
8 embodiment, the friction and/or sealing material 122  
9 comprises a single (preferably annular) band of rubber  
10 that is, for example, of 90 durometers hardness and is  
11 about 2.5 inches (approximately 28mm) wide by around  
12 0.12 inches (approximately 3mm) deep.

13  
14 To provide a zigzag pattern and hence increase the  
15 strength of the grip and/or seal that the formation 150  
16 provides in use, a number of slots 124a, 124b (e.g. 20)  
17 are milled into the band of rubber. The slots 124a,  
18 124b are typically in the order of 0.2 inches  
19 (approximately 5mm) wide by around 2 inches  
20 (approximately 50mm) long.

21  
22 To create the zigzag pattern, the slots 124a are milled  
23 at around 20 circumferentially spaced-apart locations,  
24 with around  $18^\circ$  between each along one edge 122a of the  
25 band. The process is then repeated by milling another  
26 20 slots 124b on the other side 122b of the band, the  
27 slots 124b on side 122b being circumferentially offset  
28 by  $9^\circ$  from the slots 124a on the other side 122a.

29  
30 In use, the friction and/or sealing material 122 is  
31 applied to the outer surface 120s of the (unexpanded)  
32 expandable conduit 120. It should be noted that the

1 configuration, number and spacing of the friction  
2 and/or sealing material 122 can be chosen to suit the  
3 particular application.

4

5 It should be noted that forces applied to the conduit  
6 10, 120 e.g. by subsequent movement of the conduit 10,  
7 120 that is by pushing or pulling on the conduit 10,  
8 120 for example, will be mainly transferred to the  
9 casing 12 via the anchor point and not through the  
10 inflatable device 14. This is advantageous as it  
11 reduces the risk of damage to the inflatable device 14.  
12 Additionally, this also reduces the risk of damage to  
13 the casing 12 that may have occurred where a  
14 conventional slip is used. Also, conventional slips  
15 may lose their grip on the casing 12 where damage  
16 ensues or the casing 12 is weak. Transferring  
17 substantially all of the forces directly to the casing  
18 12 via the anchor point obviates these disadvantages.

19

20 The expander device 16 can then be pulled through the  
21 expandable conduit 10, 120 to radially expand the  
22 conduit 10, 120 as shown in Fig. 1c. The expander  
23 device 16 can be propelled through the conduit 10, 120  
24 in any conventional manner. In Fig. 1, the expander  
25 device 16 is pulled through the conduit 10, 120 using a  
26 string 20 that is attached to the expander device 16 in  
27 any conventional manner.

28

29 In the embodiment shown in Fig. 1, the expander device  
30 16 is telescopically coupled to the inflatable device  
31 14 using a telescopic coupling, generally indicated at  
32 22. Coupling 22 comprises one or more telescopically



1 coupled members 24 that are attached to the inflatable  
2 device 14. As the expander device 16 is pulled  
3 upwards, the telescopic coupling 22 extends a certain  
4 distance, say 10 feet (approximately 3 metres), at  
5 which point the telescopic member(s) 24 are fully  
6 extended. At this point, the inflatable balloon-type  
7 portion 14b is automatically deflated and further  
8 upward movement of the expander device 16 causes the  
9 inflatable device 14 also to move upward, as shown in  
10 Fig. 1d.

11  
12 It should be noted that the inflatable device 14 is no  
13 longer required to anchor the conduit 10, 120 to the  
14 casing 12 as the expanded conduit 10 (Figs 1c and 1d)  
15 secure the (expanded and unexpanded) conduit 10, 120 to  
16 the casing 12. The friction and/or sealing material  
17 100, 122 is used to enhance the grip of the conduit 10,  
18 120 on the casing 12 in use, and can also provide a  
19 seal in an annulus created between the conduit 10, 120  
20 and the casing 12.

21  
22 The expander device 16 is continually pulled upwards  
23 towards the surface until the expandable conduit 10,  
24 120 is fully expanded to contact the casing 12.  
25 Thereafter, the inflatable device 14 and the expander  
26 device 16 may be removed from the expandable conduit  
27 10, 120 and/or the casing 12 at the surface.

28  
29 Anchoring and expanding the expandable conduit 10, 120  
30 in this way has several advantages. With the  
31 embodiment shown in Fig. 1, it is possible to deploy a  
32 control line or coiled tubing to control operation of

1 the inflatable device 14 and any other apparatus  
2 located in the borehole, and a control line, wireline  
3 or coiled tubing may be used to propel or pull the  
4 expander device 16. With the embodiment shown in Fig.  
5 1, there is no pressure exposure to the surrounding  
6 formation and no rig is required. With the inflatable  
7 device 14 configured as an annular ring 14r,  
8 substantially full bore access is still possible.

9  
10 It should be noted that the method described with  
11 reference to Fig. 1 is intended to expand the  
12 expandable conduit 10, 120 in a single pass of the  
13 expander device 16 through the expandable conduit 10,  
14 120, but multiple passes and/or expansions are  
15 possible.

16  
17 Referring to Fig. 2, there is shown in sequence (Figs  
18 2a to 2d) successive stages of hanging an expandable  
19 conduit 30 off a casing 32 (ie tying back a liner), the  
20 expandable conduit 30 typically comprising an  
21 expandable liner and being used to line or case a lower  
22 portion of a borehole 34, the borehole 34 typically  
23 being drilled to facilitate the recovery of  
24 hydrocarbons. The lower portion of the borehole 34 has  
25 not been lined/cased, wherein the upper portion of the  
26 borehole 34 has been lined with an existing casing or  
27 liner 36.

28  
29 In the embodiment shown in Fig. 2, the expandable  
30 conduit 30 is provided with a friction and/or sealing  
31 material 38 on an outer surface thereof. The function  
32 of the friction and/or sealing material 38 is to

1 provide a (friction and/or sealing) coupling between  
2 the expandable conduit 30 and the existing liner or  
3 casing 36. The friction and/or sealing material 38 may  
4 also provide a seal between the lower (unlined) and  
5 upper (lined) portions of the borehole 34. The  
6 friction and/or sealing material may comprise, for  
7 example, any suitable type of rubber or other resilient  
8 materials. For example, the friction and/or sealing  
9 material 38 can be configured in a similar way to the  
10 friction and/or sealing material 100, 122 described  
11 above with reference to Figs 4 to 6.

12

13 Additionally, the conduit 30 may be provided with  
14 friction and/or sealing material (e.g. material 100,  
15 122) at a lower end 301 of the conduit 30 to enhance  
16 the anchoring effect at this portion of the conduit.  
17 Additionally, the friction and/or sealing material can  
18 be provided at various spaced-apart locations along the  
19 length of the conduit 30 to enhance the coupling  
20 between the conduit 30 and the borehole 34 or casing  
21 36.

22

23 Referring to Fig. 2, an inflatable device 40, that has  
24 an expander device 42 releasably attached thereto, is  
25 positioned within the expandable conduit 30 before the  
26 conduit 30 is inserted into the borehole 34. The  
27 conduit 30 is provided with an expandable portion of  
28 casing or liner 44, portion 44 being provided with a  
29 plurality of longitudinal slots 48. The portion 44 may  
30 be located at a lower end 301 of the conduit 30 or may  
31 be integral therewith.

1 Referring to Fig. 2a, the conduit 30 with the  
2 inflatable device 40 and expander device 42 releasably  
3 attached at or near a lower end thereof, is run into  
4 the borehole 34 to the required setting depth. As can  
5 be seen in Fig. 2a, a lower end 30l of the conduit 30  
6 is radially expanded (indicated generally at 50) to  
7 allow the expander device 42 to be located therein. It  
8 will be appreciated that although Figs 2a to 2d show  
9 the inflatable device 40 and expander device 42 located  
10 at or near the lower end 30l of the conduit 30, the  
11 inflatable device 40 and/or the expander device 42 may  
12 also be located at or near an upper end of the conduit  
13 30. In this case, the expander device 42 is propelled  
14 downwardly using, for example, the weight of a string,  
15 fluid pressure or any other conventional method.

16

17 The inflatable device 40 may be of any suitable  
18 configuration, but is typically a device that has an  
19 inflatable annular balloon-type portion 40b that is  
20 mounted on an annular ring 40r. The annular ring 40r  
21 allows a string, wireline or the like to be passed  
22 through the inflatable device 40 as required. This is  
23 particularly advantageous where the inflatable device  
24 40 is positioned at the upper end of the conduit 30.

25

26 Referring to Fig. 2b, the inflatable device 40 is  
27 inflated to expand the inflatable annular balloon-type  
28 portion 40b. As the balloon-type portion 40b expands,  
29 the expandable portion 44 of conduit 30 also expands.  
30 As can be seen in Fig. 2b, the longitudinal slots 48  
31 widen as the portion 44 expands. Portion 44 acts as an  
32 anchor for the casing 30 and is expanded until it

1 contacts the borehole 34, as shown in Fig. 2b. This  
2 contact between portion 44 and the borehole 34 provides  
3 an anchor point and/or a seal between the expandable  
4 conduit 30 (to which portion 44 is attached or integral  
5 therewith) and the borehole 34.

6  
7 As with the previous embodiment, the expander device 42  
8 is then pulled through the expandable conduit 30 to  
9 radially expand the conduit 30, as shown in Fig. 2c.  
10 The expander device 42 can be propelled through the  
11 conduit 30 in any conventional manner. In Fig. 2, the  
12 expander device 42 is pulled through the conduit 30  
13 using a drill pipe or string 52 that is attached to the  
14 expander device 42 in any conventional manner.

15  
16 As the expander device 42 is pulled upwards, the upward  
17 movement thereof is stopped after a predetermined time  
18 or distance, at which point the expander device 42 is  
19 lowered until a coupling between the expander device 42  
20 and the inflatable device 40 latches. As with the  
21 previous embodiments, the inflatable annular balloon-  
22 type portion 40b is automatically deflated and further  
23 upward movement of the expander device 42 causes the  
24 inflatable device 40 also to move upward, as shown in  
25 Fig. 2d. It should be noted that the upward movement  
26 of the expander device 42 should only be stopped once a  
27 sufficient length of conduit 30 has been expanded to  
28 provide a sufficient anchor.

29

30 It should also be noted that the portion 44 is no  
31 longer required to anchor the conduit 30 to the  
32 borehole 34 as the expanded conduit 30 (Figs 2c and 2d)

1   secures the conduit 30 to the borehole 34. The  
2   friction and/or sealing material (where used) can help  
3   to provide a reliable anchor for the conduit 30 whilst  
4   it is being expanded and also when in use.

5  
6   The expander device 42 is continually pulled upwards  
7   until the conduit 30 is fully expanded, as shown in  
8   Fig. 2d. Thereafter, the inflatable device 40 and the  
9   expander device 42 may be removed from the expandable  
10  conduit 30 and the borehole at the surface. As shown  
11  in Fig. 2d, the conduit 30 expands whereby the friction  
12  and/or sealing material 38 contacts the casing 36.  
13  This provides a tie back to the casing 36 and  
14  optionally a seal between the upper (lined) portion of  
15  the wellbore and the lower (lined) borehole 34,  
16  depending upon the composition of the material 38.

17  
18  With the embodiment shown in Fig. 2, there is no  
19  pressure exposure to the formation, full bore access is  
20  still possible, the conduit 30 may be expanded in a  
21  single pass (multiple passes possible) and it may be  
22  used to anchor and set in an open hole. Additionally,  
23  it provides a tie back to the casing 36 in a single  
24  pass of the expander device 42. It should be noted  
25  that the method described with reference to Fig. 2 is  
26  intended to tie back the casing in a single pass, but  
27  multiple passes and/or expansions are possible.

28  
29  It should also be noted that successive lengths of  
30  expandable conduit may be coupled to casings or liners  
31  thereabove using the same method. Thus, the method(s)

1 described herein may be used to line or case a borehole  
2 without the use of cement.

3

4 Referring to Fig. 3, there is shown in sequence (Figs  
5 3a to 3d) successive stages of anchoring an expandable  
6 conduit 80 to a casing 82 provided in a borehole (not  
7 shown), the borehole typically being drilled to  
8 facilitate the recovery of hydrocarbons.

9

10 An inflatable device 84 is releasably attached to a  
11 lower end 801 of the expandable conduit 80 before the  
12 conduit 80 is inserted into the casing 82. The  
13 expander device 86 is located within the lower end 801  
14 of the conduit 80, the lower end 801 being expanded to  
15 accommodate the expander device 86. Similar to the  
16 previous embodiment, the inflatable device 84 has the  
17 expander device 86 releasably coupled thereto via a  
18 coupling 88. Otherwise, the inflatable device 84 and  
19 the expander device 86 are substantially the same as  
20 the previous embodiments.

21

22 Referring to Fig. 3a, the casing 80 with the inflatable  
23 device 84 attached thereto and the expander device 86  
24 located therein is run into the hole to the required  
25 setting depth. It will be appreciated that although  
26 Figs 3a to 3d show the inflatable device 84 releasably  
27 attached to the lower end 801 of the conduit 80, the  
28 inflatable device 84 may be releasably attached at or  
29 near an upper end of the conduit 80.

30

31 The inflatable device 84 may be of any suitable  
32 configuration, but is typically a device that has an

1 inflatable annular balloon-type portion 84b that is  
2 mounted on an annular ring 84r. The annular ring 84r  
3 allows a string, wireline or the like to be passed  
4 through the inflatable device 84 as required. This is  
5 particularly advantageous where the inflatable device  
6 84 and/or the expander device 86 are positioned at the  
7 upper end of the conduit 80.

8  
9 Referring to Fig. 3b, the inflatable device 84 is  
10 inflated to expand the inflatable annular balloon-type  
11 portion 84b. As the balloon-type portion 84b expands,  
12 it contacts the casing 82, thus providing an anchor  
13 between the conduit 80 and the casing 82. This contact  
14 between the balloon-type portion 84b and the casing 82  
15 provides an anchor point and/or a seal between the  
16 conduit 80 and the casing 82.

17  
18 It should be noted that in this embodiment, the forces  
19 applied to the conduit 80 by subsequent movement of the  
20 conduit 80, that is by pushing or pulling on the  
21 conduit 80 for example, will be transferred to the  
22 casing 82 via the inflatable device 84. However,  
23 unlike conventional slips, the inflated balloon-type  
24 portion 84b is less likely to damage the casing.  
25 Additionally, the size of the balloon-type portion 84b  
26 can be chosen whereby it is sufficiently large so as  
27 not to lose its grip on the casing 82, even when the  
28 inflatable device 84 is moved upwardly or downwardly.

29  
30 The expander device 86 is pulled through the expandable  
31 conduit 80 to radially expand the conduit 80, as shown  
32 in Fig. 3c. The expander device 86 can be propelled



1 through the conduit 80 in any conventional manner, as  
2 with the previous embodiments.

3

4 Also, and as with the previous embodiments, an outer  
5 surface 80s of the conduit 80 can be provided with a  
6 friction and/or sealing material. The friction and/or  
7 sealing material may comprise, for example, any  
8 suitable type of rubber or other resilient materials.  
9 For example, the friction and/or sealing material can  
10 be configured in a similar way to the friction and/or  
11 sealing material 100, 122 described above with  
12 reference to Figs 4 to 6.

13

14 Additionally, the conduit 80 may be provided with  
15 friction and/or sealing material (e.g. material 100,  
16 122) at a lower end 80l of the conduit 80 to enhance  
17 the anchoring effect at this portion of the conduit 80.  
18 Additionally, the friction and/or sealing material can  
19 be provided at various spaced-apart locations along the  
20 length of the conduit 80 to enhance the coupling  
21 between the conduit 80 and the casing 82.

22

23 As the expander device 86 is pulled upwards, the upward  
24 movement thereof is stopped after a predetermined time  
25 or distance, at which point the expander device 84 is  
26 lowered until the coupling 88 between the expander  
27 device 86 and the inflatable device 86 latches. As  
28 with the previous embodiments, the inflatable balloon-  
29 type portion 84b is automatically deflated and further  
30 upward movement of the expander device 86 causes the  
31 inflatable device 84 also to move upward, as shown in  
32 Fig. 3d. It should be noted that the upward movement

1 of the expander device 86 should only be stopped once a  
2 sufficient length of conduit 80 has been expanded to  
3 provide a sufficient anchor.

4  
5 The expander device 86 is continually pulled upwards  
6 towards the surface until the conduit 80 is fully  
7 expanded to contact the casing 82. Thereafter, the  
8 inflatable device 84 and the expander device 86 may be  
9 removed from the borehole at the surface.

10  
11 Anchoring and expanding the conduit 80 in this way has  
12 the same advantages as in the previous embodiment, but  
13 the Fig. 3 embodiment is designed to anchor and set in  
14 cased hole rather than open hole.

15  
16 The method and apparatus described herein may be used  
17 for a plurality of different downhole functions  
18 relating to the use of expandable conduit. For  
19 example, they may be used where the original liner or  
20 casing requires to be repaired due to damage or the  
21 like by overlaying the damaged portion with a portion  
22 of expandable conduit. They may also be used to tie  
23 back to the liner or casing, as described herein.

24  
25 Thus, there is provided in certain embodiments an  
26 apparatus and method of anchoring an expandable conduit  
27 to a second conduit. The apparatus and method of  
28 certain embodiments provide numerous advantages over  
29 conventional mechanical anchoring devices, such as  
30 slips, particularly by reducing the potential damage to  
31 conduits that mechanical slips may cause. Certain  
32 embodiments of apparatus and methods involve the use of

1 an inflatable device that can either be a) attached  
2 directly at or near the top or bottom of the expandable  
3 conduit, or b) placed within the top or bottom of the  
4 expandable conduit. In a), anchoring forces are  
5 generated as a result of friction between the  
6 inflatable device and the second conduit, the forces  
7 being passed into the conduit via the inflatable  
8 device. In b), anchoring forces are generated by  
9 friction between an outer surface of the expandable  
10 conduit and the second conduit, the forces being  
11 substantially passed into the second conduit directly  
12 via the expandable conduit. The outer surface of the  
13 expandable conduit may be suitably prepared (ie  
14 provided with a friction enhancing material) to  
15 increase the strength of the anchor.  
16  
17 Modifications and improvements may be made to the  
18 foregoing without departing from the scope of the  
19 present invention.

## 1 CLAIMS

2 1. Apparatus for anchoring a first conduit to a  
3 second conduit, the apparatus comprising an inflatable  
4 device for engaging with the first conduit, wherein the  
5 inflatable device is inflatable to facilitate anchoring  
6 of the first conduit to the second conduit.

7

8 2. Apparatus according to claim 1, wherein the first  
9 conduit is an expandable conduit.

10

11 3. Apparatus according to claim 1 or claim 2, wherein  
12 the first conduit comprises any type of expandable  
13 conduit that is capable of sustaining plastic and/or  
14 elastic deformation.

15

16 4. Apparatus according to any preceding claim,  
17 wherein the first conduit comprises an expandable  
18 liner, casing or the like.

19

20 5. Apparatus according to any preceding claim,  
21 wherein the second conduit comprises a liner, casing,  
22 borehole or the like.

23

24 6. Apparatus according to any preceding claim,  
25 wherein the inflatable device comprises an inflatable  
26 balloon-type portion coupled to a ring.

27

28 7. Apparatus according to any preceding claim,  
29 wherein the inflatable device includes an expander  
30 device.

31

1 8. Apparatus according to claim 7, wherein the  
2 expander device is telescopically coupled to the  
3 inflatable device, so that when the expander device is  
4 moved a certain distance, the inflatable device is  
5 deflated and subsequently moves with the expander  
6 device.

7

8 9. Apparatus according to claim 7, wherein the  
9 expander device is releasably attached to the  
10 inflatable device.

11

12 10. Apparatus according to claim 9, wherein the  
13 expander device is releasably attached to the  
14 inflatable device using a latch mechanism.

15

16 11. Apparatus according to any preceding claim,  
17 wherein the inflatable device is located within the  
18 expandable conduit.

19

20 12. Apparatus according to any one of claims 1 to 11,  
21 wherein the inflatable device is coupled at or near an  
22 upper end of the expandable conduit, or at or near a  
23 lower end of the expandable conduit.

24

25 13. Apparatus according to any preceding claim  
26 wherein the inflatable device is inflated to expand the  
27 expandable conduit whereby the expandable conduit  
28 contacts the second conduit, thereby providing an  
29 anchor.

30

1 14. Apparatus according to claim 13, wherein the  
2 expandable conduit is provided with a slotted portion  
3 to facilitate expansion.  
4

5 15. Apparatus according to any one of claims 1 to 12,  
6 wherein the inflatable device is inflated whereby a  
7 portion thereof directly contacts the second conduit to  
8 provide an anchor.  
9

10 16. A method of anchoring a first conduit to a second  
11 conduit, the method comprising the steps of providing a  
12 first conduit, providing an inflatable device in  
13 contact with the first conduit, running the first  
14 conduit and inflatable device into the second conduit,  
15 and subsequently inflating the inflatable device to  
16 facilitate anchoring of the first conduit to the second  
17 conduit.  
18

19 17. A method of anchoring an expandable conduit to a  
20 second conduit, the method comprising the steps of  
21 providing an expandable conduit, running the first  
22 conduit into the second conduit, passing an inflatable  
23 device into the conduit, and subsequently inflating the  
24 inflatable device to facilitate anchoring of the  
25 expandable conduit to the second conduit.  
26

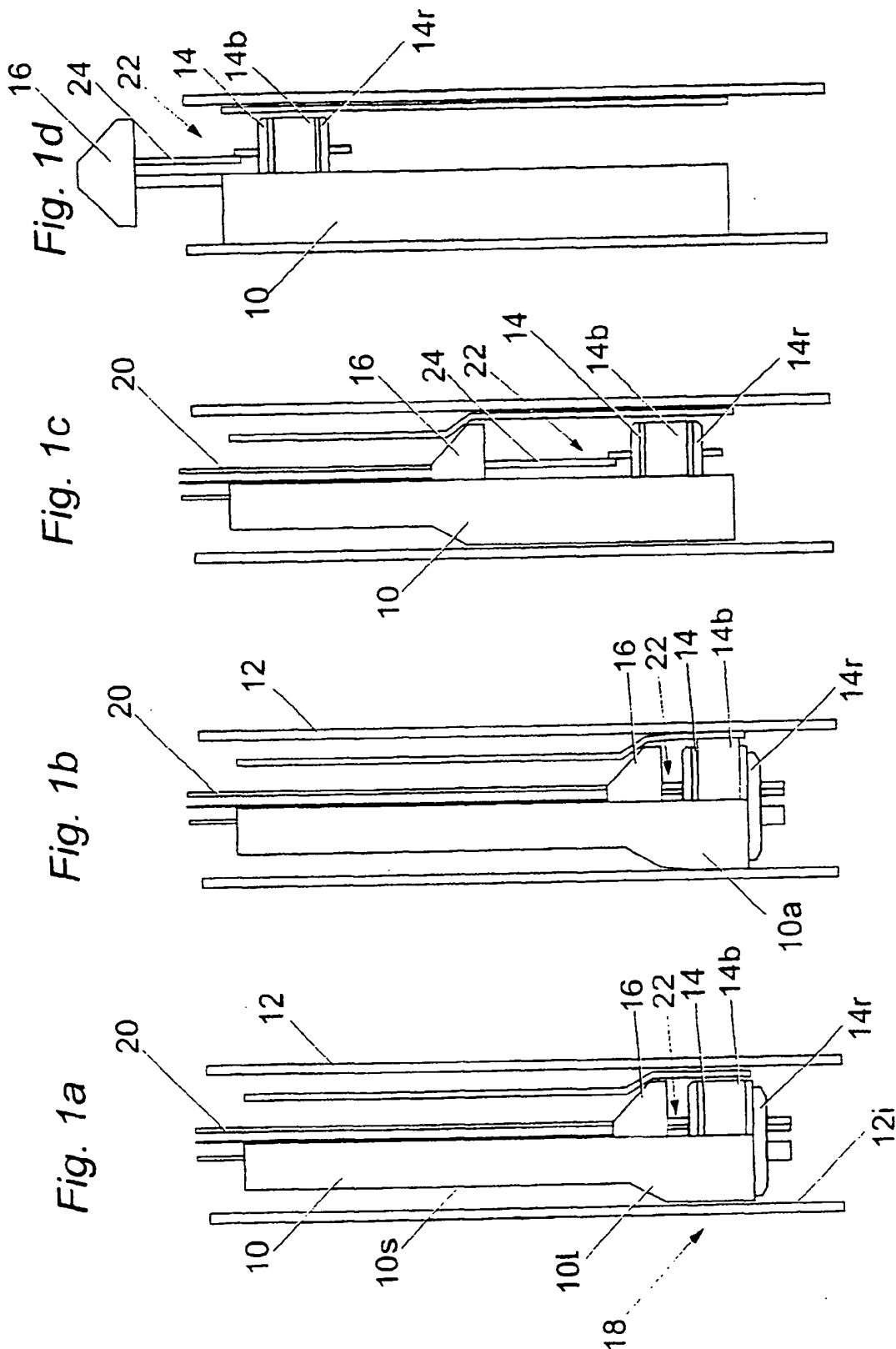
27 18. A method according to claim 16 or claim 17,  
28 wherein the method includes one, some or all of the  
29 additional steps of inserting an expander device into  
30 the expandable conduit, operating the expander device  
31 to expand the expandable conduit, deflating the  
32 inflatable device, and removing the expander device

1 and/or the inflatable device from the expandable  
2 conduit and/or the second conduit.

3

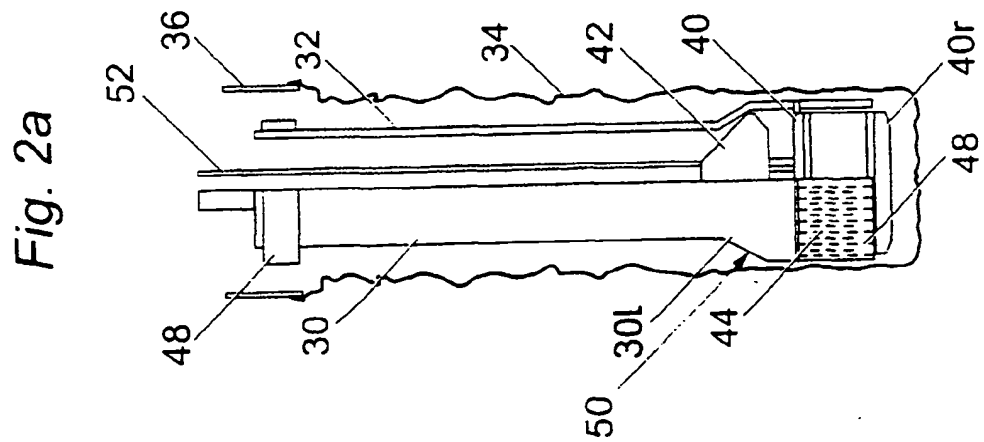
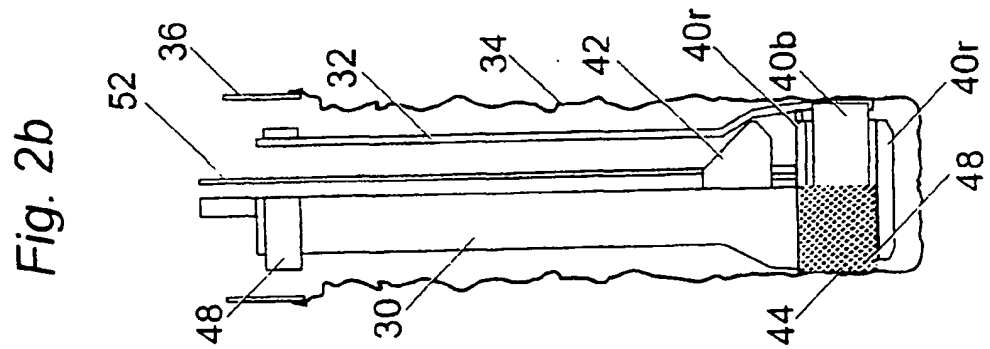
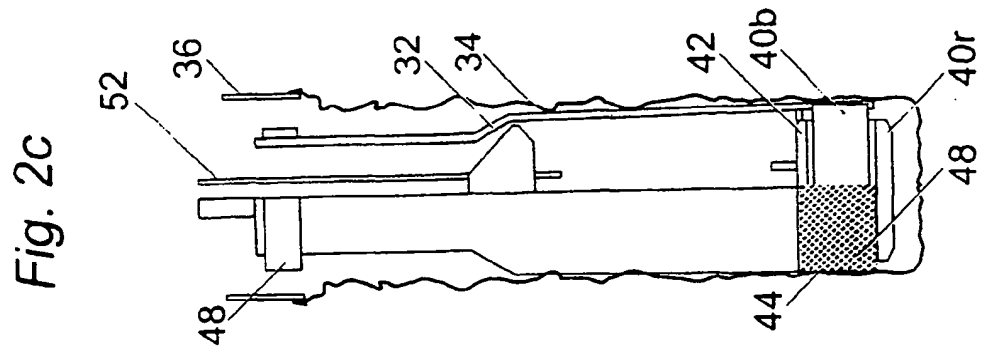
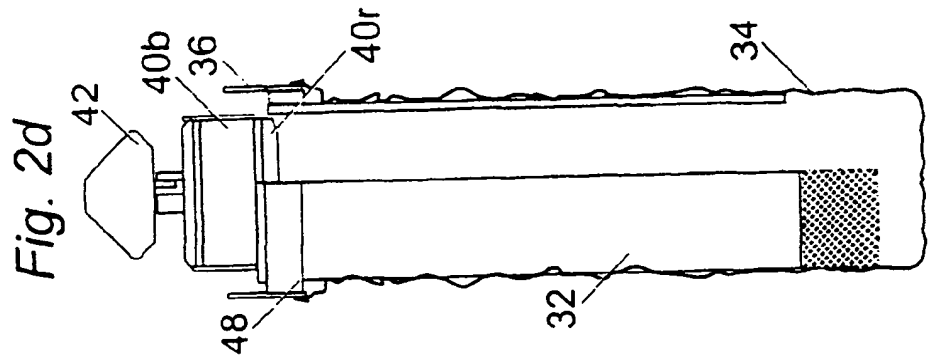
4 19. A method according to any one of claims 16 to 18,  
5 wherein the method includes one, some or all of the  
6 additional steps of attaching an expander device to the  
7 inflatable device, operating the expander device to  
8 expand the expandable conduit, re-attaching the  
9 expander device to the inflatable device, deflating the  
10 inflatable device, and removing the expander device  
11 and/or the inflatable device from the expandable  
12 conduit and/or second conduit.

1 / 6

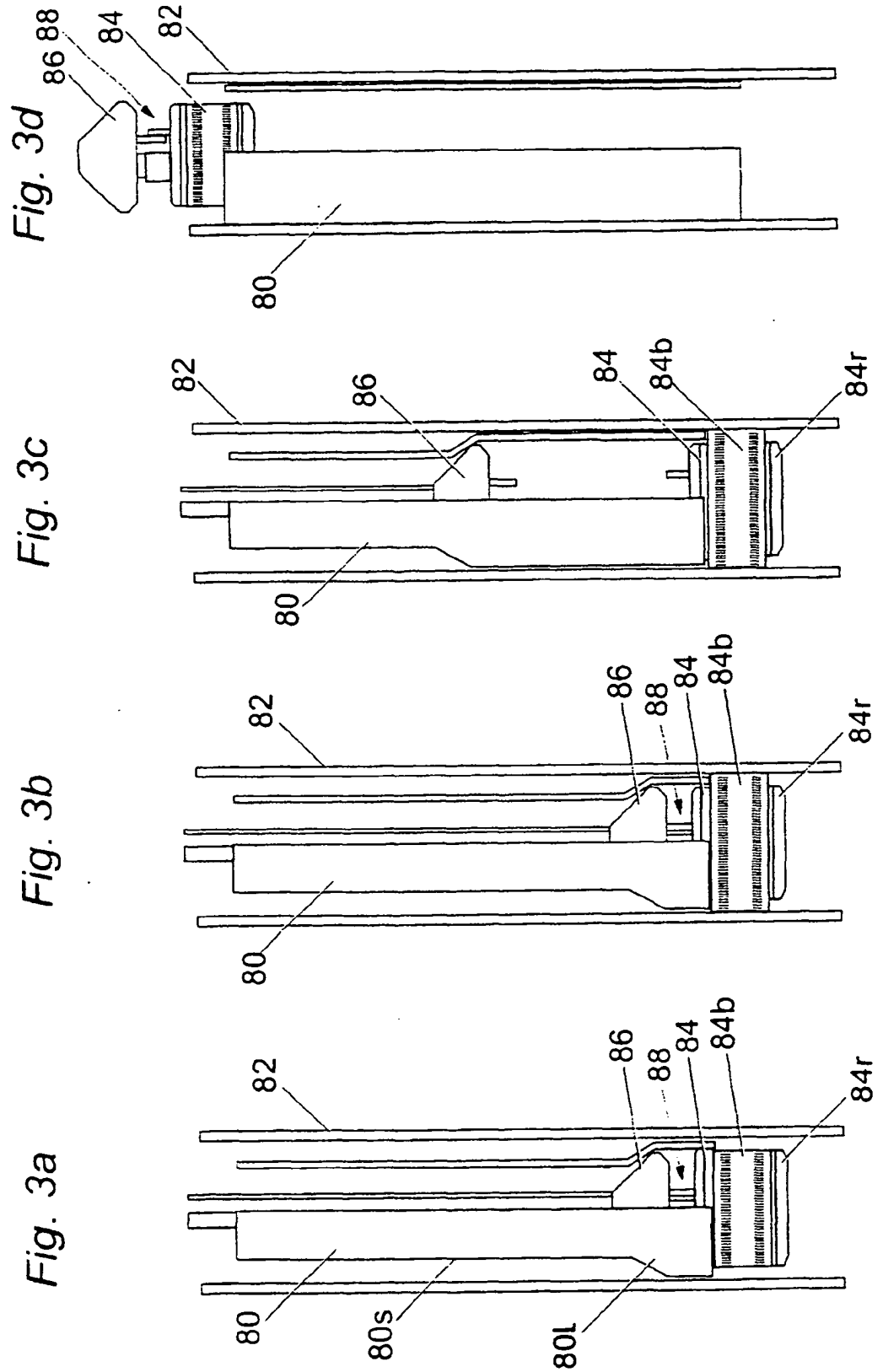


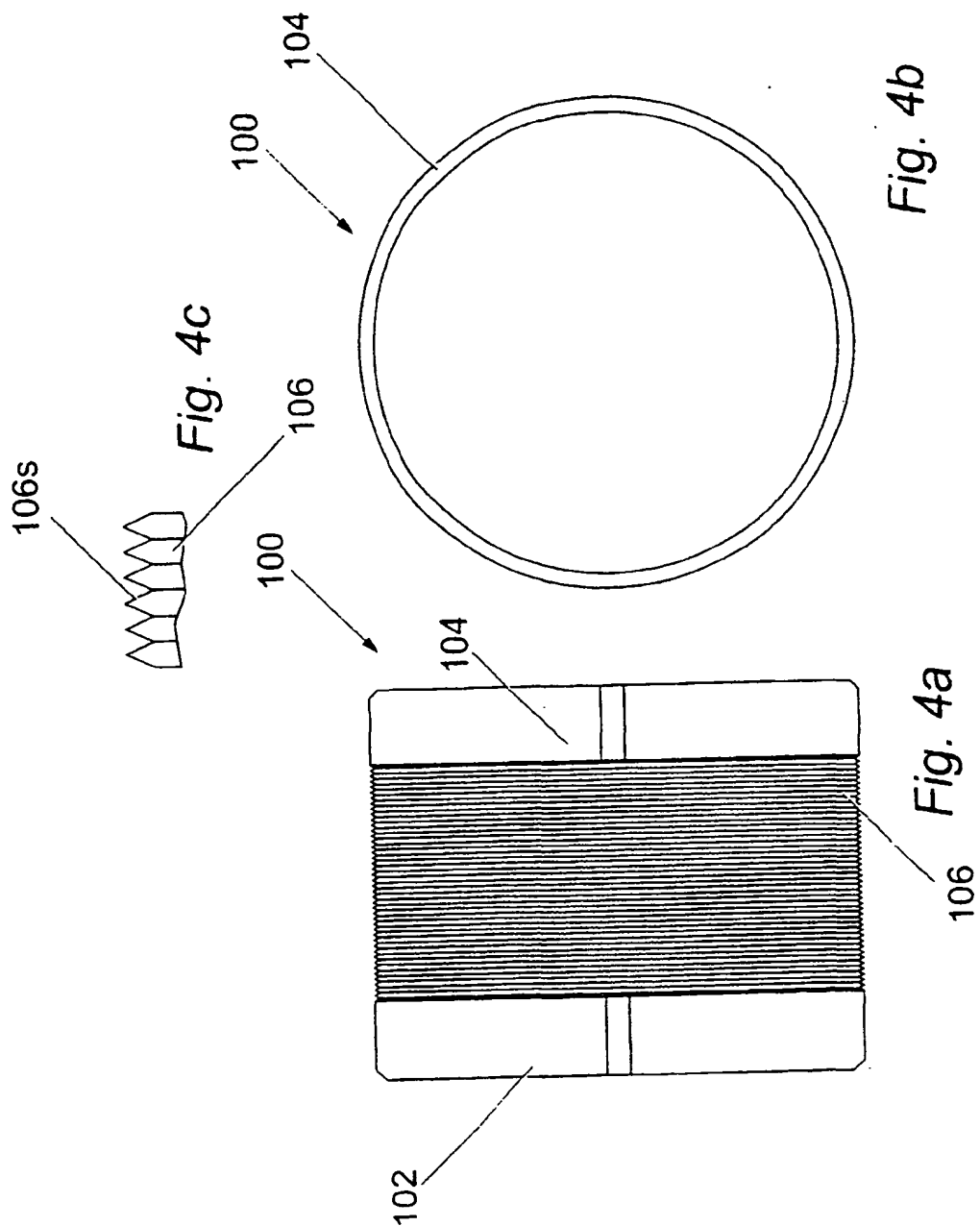


2 / 6



3 / 6





5 / 6

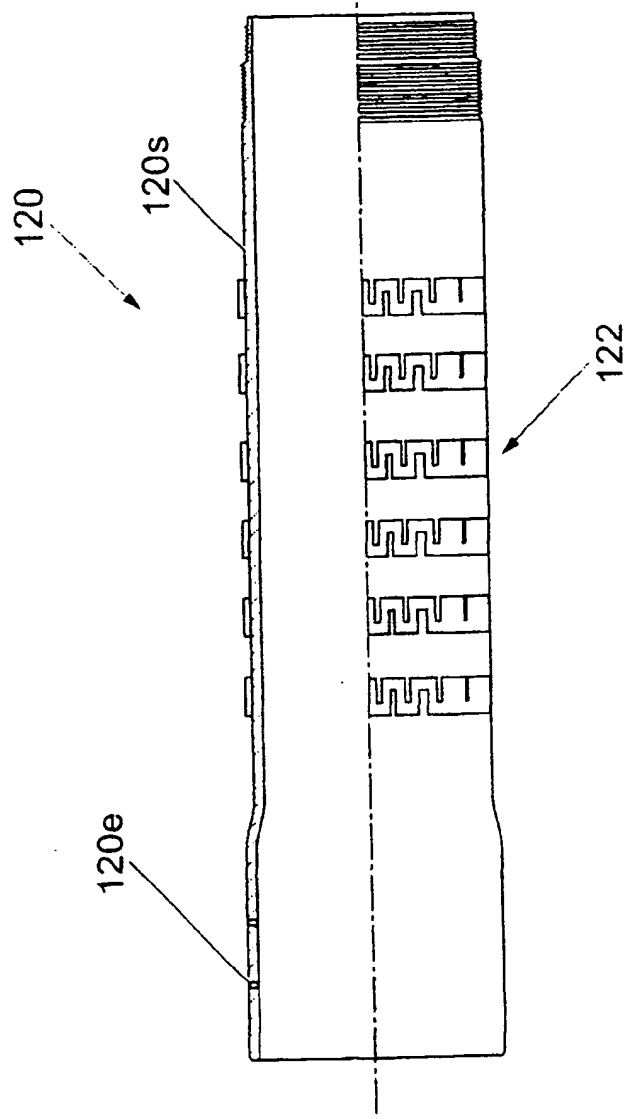


Fig. 5

6 / 6

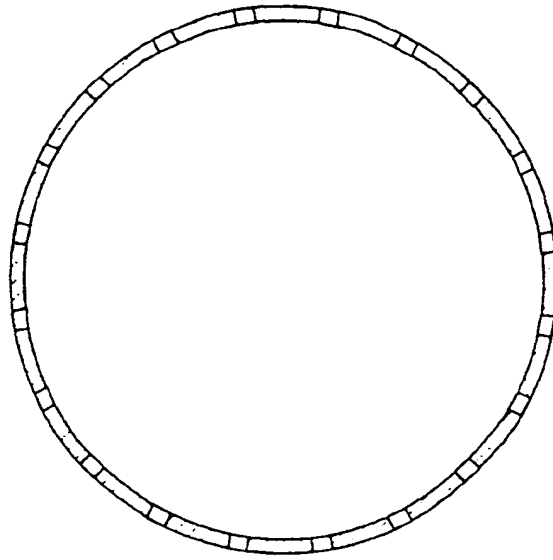


Fig. 6b

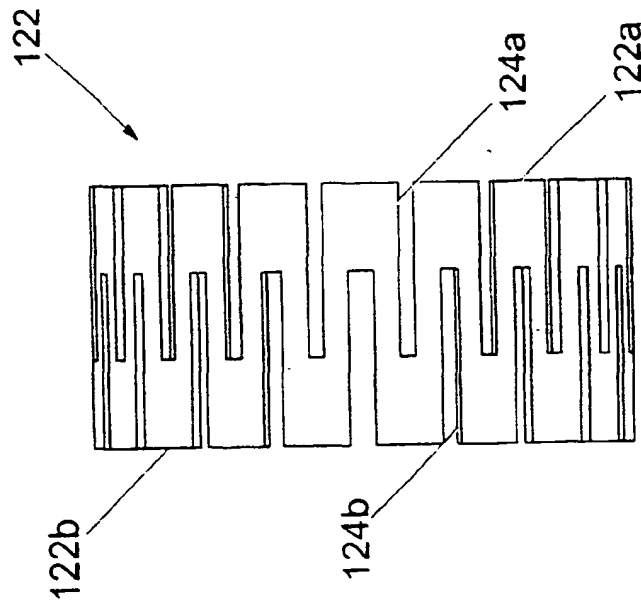


Fig. 6a

# INTERNATIONAL SEARCH REPORT

Int. l. Application No  
PCT/GB 00/03406

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 695 008 A (SALTEL JEAN-LOUIS ET AL) 9 December 1997 (1997-12-09)  column 6, line 33 - line 43	1-5, 7, 11, 13, 16, 18
X	EP 0 842 348 A (DRILLFLEX) 20 May 1998 (1998-05-20) the whole document	1-7, 11, 13, 16, 18
A	WO 99 23354 A (METCALFE PAUL DAVID ;PETROLINE WELLSYSTEMS LTD (GB)) 14 May 1999 (1999-05-14) page 8, line 17 -page 9, line 3	1-19
P, A	GB 2 344 606 A (SHELL INT RESEARCH) 14 June 2000 (2000-06-14) abstract; figures 1-11	1-19

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*3\* document member of the same patent family

Date of the actual completion of the international search

17 November 2000

Date of mailing of the international search report

24/11/2000

Name and mailing address of the ISA  
European Patent Office, P.B. 5816 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Garrido Garcia, M

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/03406

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5695008 A	09-12-1997	FR 2704898 A	10-11-1994
		AU 673261 B	31-10-1996
		AU 6660194 A	21-11-1994
		CA 2162035 A	10-11-1994
		CN 1122619 A, B	15-05-1996
		DE 69412252 D	10-09-1998
		DE 69412252 T	06-05-1999
		EP 0698136 A	28-02-1996
		WO 9425655 A	10-11-1994
		JP 8509532 T	08-10-1996
		NO 954299 A	07-12-1995
		RU 2123571 C	20-12-1998
EP 0842348 A	20-05-1998	FR 2737533 A	07-02-1997
		AT 194686 T	15-07-2000
		AU 696825 B	17-09-1998
		AU 6744196 A	05-03-1997
		DE 69609333 D	17-08-2000
		JP 11510229 T	07-09-1999
		NO 980428 A	03-04-1998
		US 6044906 A	04-04-2000
		CA 2228732 A	20-02-1997
		CN 1195389 A	07-10-1998
		WO 9706346 A	20-02-1997
WO 9923354 A	14-05-1999	AU 9753598 A	24-05-1999
		EP 1027526 A	16-08-2000
		NO 20001956 A	19-06-2000
GB 2344606 A	14-06-2000	AU 5933599 A	08-06-2000
		BR 9906143 A	05-09-2000
		DE 19958399 A	13-07-2000
		NO 995991 A	08-06-2000

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☒ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☒ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER: \_\_\_\_\_**

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**